THE ELECTRICAL CONDUCTIVITY OF INDIUM AND THALLIUM.

Alpheus W. Smith.

The behavior of the electrical conductivity of metals when the metal passes from the solid to the liquid condition is of increasing interest and importance in the formation of an electron theory of metallic conduction. Except for the excellent work of Northrup,* little systematic work has been done in this field. It is the purpose of this short paper to give some results obtained for indium and thallium.

In order to make possible observations on the metal in the liquid as well as in the solid condition, the metal to be studied was introduced into a glass tube one end of which was closed. Four platinum wires were sealed into this tube so that they were at right angles to its axis. Two of these wires served as potential and two as current electrodes in the ordinary Thomson double bridge method of comparing low resistances. This glass tube was about 3 mm. in internal diameter and the distance between the potential electrodes was about 2 cm. A sufficient quantity of the metal was introduced to fill the tube above the platinum electrode farthest from the closed end. The air was exhausted from the tube and it was then sealed off to prevent the oxidation of the metal on fusion. After fusion the metal was allowed to cool slowly from the liquid to the solid state.

In order to secure the necessary temperatures for these observations a cylindrical electrical furnace wound with nichrome wire was used, except for room temperature and the temperature of melting ice. The temperatures were determined by means of a mercury in glass thermometer which was filled with nitrogen. The observations on the resistances were made in the usual way with a Thomson double bridge which was obtained from Wolff. The standard low resistance was a coil had a resistance of 0.001 ohm at 20 C. The indium and thallium were obtained from Merck & Co. No chemical analysis was made of them and no attempt to further purify them.

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* Jour. Franklin Inst. 175, pp. 153–161 (1913).

In order to calculate the specific resistance of the indium the specific resistance at 0° C. was taken as 8.37 x 10^{-6} ohms. This is the value found by Erhard† who made his observations on indium in the form of wires. Taking this value as known the value of the specific resistance for any other temperature could be at once calculated. In the case of thallium the value by Dewar and Fleming‡ was assumed to be correct. These

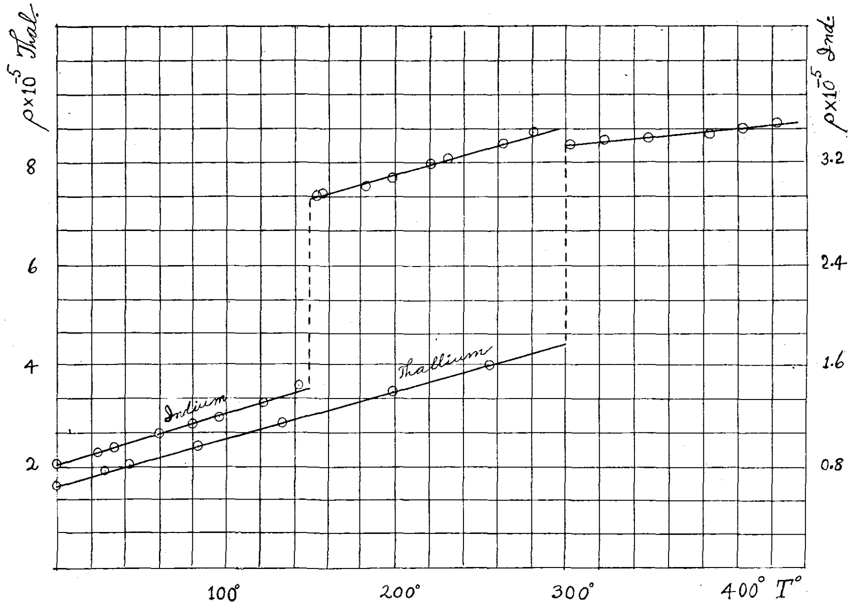

Figure 1

observers found the specific resistance of thallium to be 17.60 x 10^{-6} ohm at 0° C. From this value the other values for the specific resistance were calculated.

The results of these observations have been given in Table I and have also been plotted in the accompanying figure 1 in which the ordinates are the specific resistances in ohms and the abscissæ are the temperatures. Some of the observations were made with increasing and some with decreasing temperature. In each of these cases is seen the characteristic discontinuity in the curve at the melting point of the metal. In each of these

† Erhard, W. A., 14 p. 504 (1881).

‡Dewar and Fleming, Phil. Mag. (5) 36, p. 271 (1893).

two metals the resistance in the solid as well as in the liquid state is nearly a linear function of the temperature. The rate at which the resistance increases with the temperature is less in the liquid than in the solid state.

TABLE I.

Indium		Thallium	
Temp.	$\rho \times 10^6$	Temp.	$\rho \times 10^6$
0°	8.37	0°	17.60
24.1	9.27	28.4	19.59
34.7	9.62	41.8	21.11
60.2	10.85	45.1	21.31
80.4	11.48	83.0	24.46
86.4	11.98	84.7	24.62
121.4	13.09	133.2	28.72
141.8	14.56	135.0	29.09
142.7	14.63	197.5	35.10
154.0	29.10	198.0	35.14
156.8	29.28	254.0	40.16
166.8	29.66	258.2	40.22
181.5	30.11	301.7	83.38
182.8	30.13	302.5	83.60
198.5	30.84	305.5	83.61
220.0	31.87	309.0	83.89
230.0	32.29	321.0	84.32
261.0	33.31	347.0	84.84
280.2	34.87	356.0	85.35
		367.4	85.34
		382.0	85.95
		401.5	86.78
		422.0	87.54

TABLE II.

Metal	$\frac{1}{R_0}\left(\frac{\partial R}{\partial t}\right) \times 10^3$	$\frac{1}{R_0}\left(\frac{\partial R}{\partial t}\right) \times 10^3$	R_l/R_s
Indium..........	5.24	3.98	2.00
Thallium........	5.27	1.95	1.90

Table II gives the temperature coefficient of the resistance of thallium and indium before and after melting. The second column gives this coefficient before melting; the third column, after melting. In the last column of this table is the ratio of the resistance before and after fusion. Within the error of observation this ratio is 2.00 for indium and 1.90 for thallium.

The temperature coefficients of the resistance here recorded are somewhat larger than those found by Erhard for indium and by Dewar and Fleming for thallium. The former working between —5.4° C. and 96° C. gives for the temperature coefficient of indium 4.77×10^{-3}, the latter working between 0° and 100° gives for the temperature coefficient of thallium 3.98×10^{-3}. These discrepancies are probably due to impurities and to mechanical treatment of the specimens.

I wish to express my thanks to the Rumford Committee which bore part of the expense of this investigation.

Physical Laboratory, Ohio State University.